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THE ORIGIN AND DISTRIBUTION OF SILICA MINERAL ON THE RECENT SURFACE SEDIMENT AREA, NORTHERN COASTLINE OF RUPAT ISLAND, INDONESIA

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ABSTRACT

Rupat Island is a part of Bengkalis district, Riau province, Indonesia with the total area is 1,500 km2. The main formations in this island are Older Surface Sediment (Qp) and Recent Surface Sediment (Qh) with the recent age of both. Silica sand distributes only on the northern coastline of Rupat Island from Tanjung Mumbul until Pasir Putih area. Samples were collected and measured from five locations, which are Beting Aceh (BA) Tanjung Api (TAp), Teluk Rhu (TRh), Tanjung Punai (TPn) and Tanjung Lapin (TLp). From these locations, homogeneous characteristic of silica sand can be found as a white color. Silica sand source on Rupat Island came from sediment that carried by the sea-flow of Malacca Strait as the sediment transport agent, it was shown by the characteristic of the grain which is the round-shape and same size that were conducted by using microscopic photograph testing. Laboratory tests using the XRF (X-Ray Fluorescence) and XRD (X-Ray Diffraction) showed the silica compound (SiO_2) has a high percentage above 95%.

Keywords: silica mineral, rupat Island, Malacca strait, x-ray fluorescence, x-ray diffraction.

1. INTRODUCTION

Silica mineral is one of the minerals which relatively abundant in Indonesia. This is possible due to Indonesia geological condition, which is almost as acidic igneous rock that formed mineral source [1]. Silica mineral is acidic weathering of igneous rocks such as granite, gneiss or other igneous rock containing major mineral quartz. The quality of silica mineral in Indonesia is quite varied, depending on the process and the influence of mineral genesis impurities formed during sedimentation processes involved.

In Nature, silica mineral found with varied grain size, fine grain size (< 0.06 mm) located far from source rock and (> 2 mm) located not far from the source rock [2]. Crystalline of quartz (SiO_2) mostly white, with a white spout and polish glass. With imperfect parts and pieces that are not flat (conchoidal), mineral crystal has a hexagonal bipyramid prism, has a specific gravity 2.65 kg/m^3 and hardness is 7 (Mohs scale) and it has outstanding durability in the process of abrasion/erosion. Melt at a temperature of 1,710° C [3]. When experience rapid cooling, will provide an amorphous texture.

This mineral was used in the industry such as building materials and the main ingredient in the design of interior/exterior [4, 5] as well as materials for household need. As the followed material, silica mineral used for printed materials in the foundry [5, 7, 8], refractory materials and as filler in the mining and petroleum industry [9], especially when performing drilling activities.

Rupat Island (Figure-1) is a part of Bengkalis district which located in front of Dumai City, Indonesia. Rupat Island has a breadth of 1,500 km^2. Geological setting of this island consists of Recent Surface Sediment formation (Qh) and Older Surface Sediment formation (Qp). The high silica content accumulated with other compounds in the silica sand found at the Bukit Pelintung area which is located nearby from Rupat Island [10].

The purpose of this study is to know the percentage, the origin and the distribution of silica mineral in Rupat Island also to conduct an inventory and determine the potential (characterization and utilization) of silica mineral resources in the Rupat Island, Bengkalis district, Riau province, Indonesia.

2. GEOLOGICAL CONDITION

Rupat Island located in the north of Central Sumatra Basin and directly opposite the straits of Malacca [11]. The geological structure of the northern part of Central Sumatra Basin was developing at the time of Neogen and asymmetrical shape that led northwest-southeast (NW-SE) which is a pattern of young structure. The deepest part lies in the southwest part and sloping toward to the northeast. It is because of the appearance fracture faults in the base of basin that is generally half graben shaped. The bedrock of the northern part of Central Sumatra Basin is Quartzite Terrane, also called Mallaca Terrane, consists of quartzite, crystalline limestone, schist and shale with aged 295 m.a and 112-122 m.a, 150 m.a, respectively. This bedrock intruded by granitic pluton and granodioritic with Jura age. This group is found in the north to the northeast of coastal plain and Rupat Island has quartzite as its bedrock.

Rupat Island is part of the Telisa formation. This formation is deposited as the repetition filled with Bekasap and Duri formations on the southwest and northeast, respectively [12]. In some places also found parallel deposition with those formations. This formation started from early Miocene to middle Miocene consists of a succession of sedimentary rocks dominated by shale with calcareous siltstone inserted with gray color, brown and sometimes encountered with limestone.

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The depositional environment for this formation started from neritic to non-marine [13, 14, 15]. (Dawson 1997). One event that is quite important in Central Sumatra Basin is the emergence of igneous intrusion and extrusion aged on the middle Miocene (12-17 m.a) shortly after a hiatus of Duri. The composition of intrusive rocks shows the depositional environment of the Back-arc Basin [16, 17, 18].

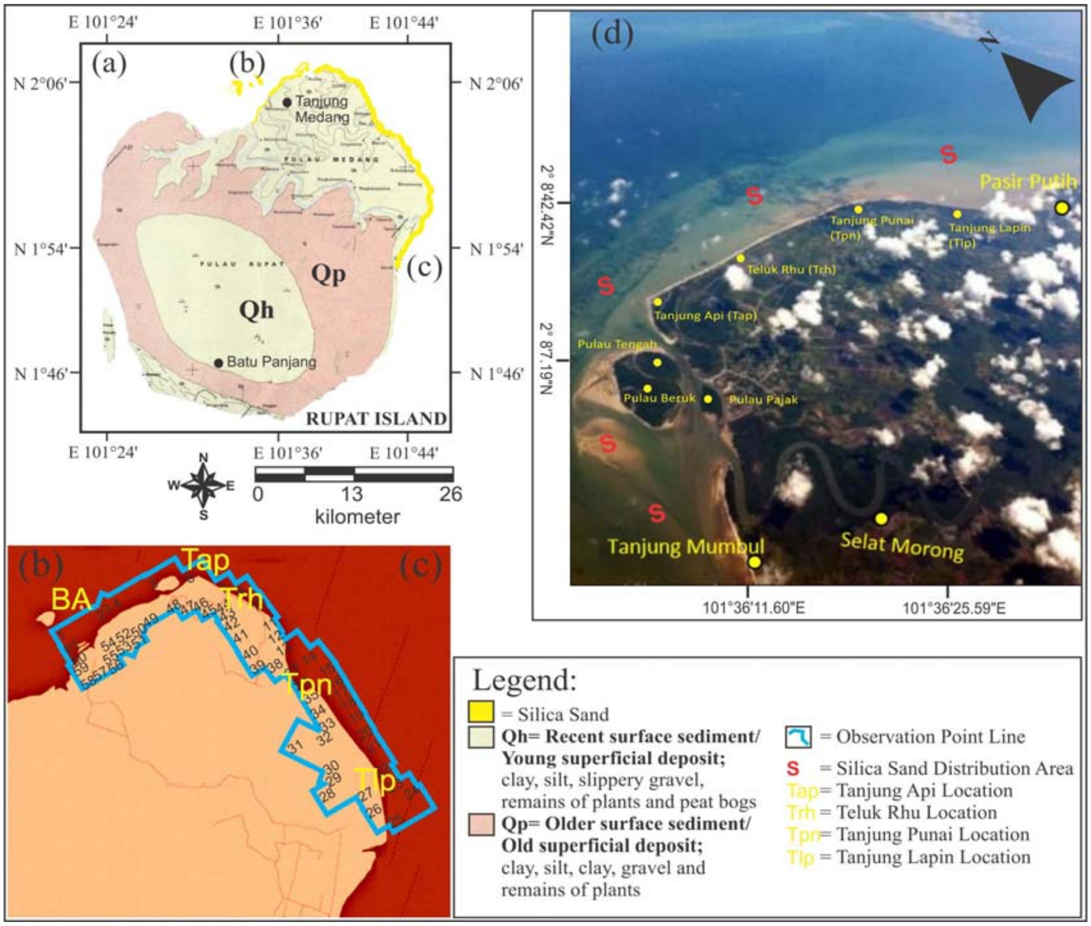

Figure-1. (a) Geological map of Rupat island, (b) - (c) Insert of field observation points, (d) Aerial photograph of Silica mineral distribution at Northern coastline of Rupat island (Scale only for insertion (a)).

The upper part of Rupat Island is composed of two formations; they are and Older Surface Sediment formation (Qp) and Recent Surface Sediment formation (Qh). Old Superficial Deposit formation (Qp) consisting of clay, silt, clay, gravel and remains of plants. Young Superficial Deposit formation (Qh) consisting of clay, silt, gravel slippery, remains of plants and peat bogs. These formations are the recent age. The northern part of Rupat Island facing the Malacca Strait and rich with sand sediment reserve. The southern of this island facing Dumai City, coastal beach had more material with rich of mud sediment.

3. METHODOLOGY

This study covered by the plotting of observation points, the observation of sand outcrops, sampling and the laboratory analysis. Observation on the field at Rupat Utara subdistrict (northern part of Rupat Island) started in the area along the coastline location, these areas are: Tanjung Mumbul, Pulau Simpur, Pulau Kemunting, Pulau Babi, Beting Aceh, Pulau Pajak, Pulau Beruk, Pulau Tengah, Tanjung Medang, Teluk Rhu, Tanjung Punai, Tanjung Lapin, Pasir Putih. Based on observation on the field, there are five main observation locations (Figure-2) were chosen as the represented study area along the northern coastline of Rupat Island, there are; Beting Aceh (BA), Tanjung Api (TAp), Teluk Rhu (TRh), Tanjung Punai (TPn) and Tanjung Lapin (TLp). Sand sampling was conducted. The samples were collected from those areas.

The laboratory test was conducted to get the content of minerals in these samples. X-Ray Fluorescence (XRF) and X-Ray Diffraction (XRD) were used to get that information. The microscopic photograph also used to know the shape of the fragment/grain of the mineral's composition.

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4. RESULT AND DISCUSSIONS

All samples from the observation location show the properties of sand virtually white and homogeneous by direct observation in the field. It gives the suggestion that the silica mineral composition in this region have closely the same silica content.

4.1 Distribution of Silica mineral

Field observation on the Rupat Island shows the distribution of silica mineral in this island is not located-

Figure-2. Five main observation locations on the northern coastline of Rupat Island.

along the entire coastline of the island. Silica mineral can be found only in the northern part of the coastline, start from Tanjung Mumbul until Pasir Putih area as shown in Figure-3 (also see in Figure-1).

Distribution of silica mineral in this island is heavily influenced by the current of Malacca Strait as the sediment transport agent (Figure-4). The northern part of the island Rupat is dealing directly with the Malacca Strait. Malacca Strait is located between Malaysia Peninsular and Sumatra Island. This strait is the one of meeting point between the Indian Ocean in the northwest and the South China Sea in the northeast and brought the sediment source as the transport agent from both of those seas.

4.2 The origin of Silica mineral

Silica mineral presence on the Rupat Island could not be separated from the role held by the Malacca Strait. Silica mineral was brought from the current of both seas above at Malacca Strait. The source rocks are composed of igneous rocks, which had been abundant with quartz / silica mineral, especially the South China Sea through the Riau Islands province (which is known as the very rich igneous rock's area) before entering the Malacca Strait.

The origin of Silica mineral on Rupat Island is not from the bedrock of this island. The northern island which facing the Malacca Strait gains sand sediment supply from the waterway flows. Malacca Strait transports the sand sediment material from the Indian Ocean at northwestern, while in the northeastern, sand sediment materials was obtained from the South China Sea and Riau Islands (see Figure-4). There are many sources of sand at the northern part of this island. This is because the current that carried the sediment source was blocked at the northern part of the Rupat Island and deposited the sand on the northern coast of the island. The silica mineral

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comes from Malacca Strait as the transportation agent of sediment. Compared to the bedrock of Rupat Island, which consists of Recent Surface Sediment (Qh) and Older Surface Sediment (Qp), which are consisted of clay and peat as the general composition, it is impossible for these bedrocks to produce sand grain.

Apart from the bedrock of Rupat Island is unlikely to produce silica mineral, the origin of silica mineral source also proved by the result of the microscopic photograph that shows the grain shape of silica mineral particles is rounded. It suggests the source/origin of silica mineral came from the far location.

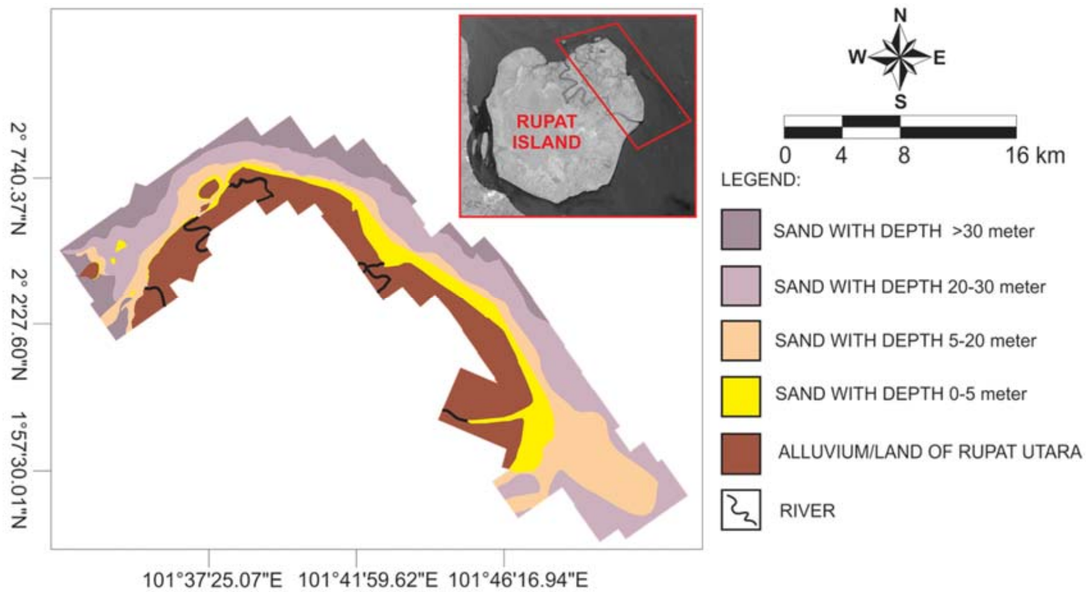

Figure-3. Estimation of silica mineral distribution on the Northern coastline of Rupat Island.

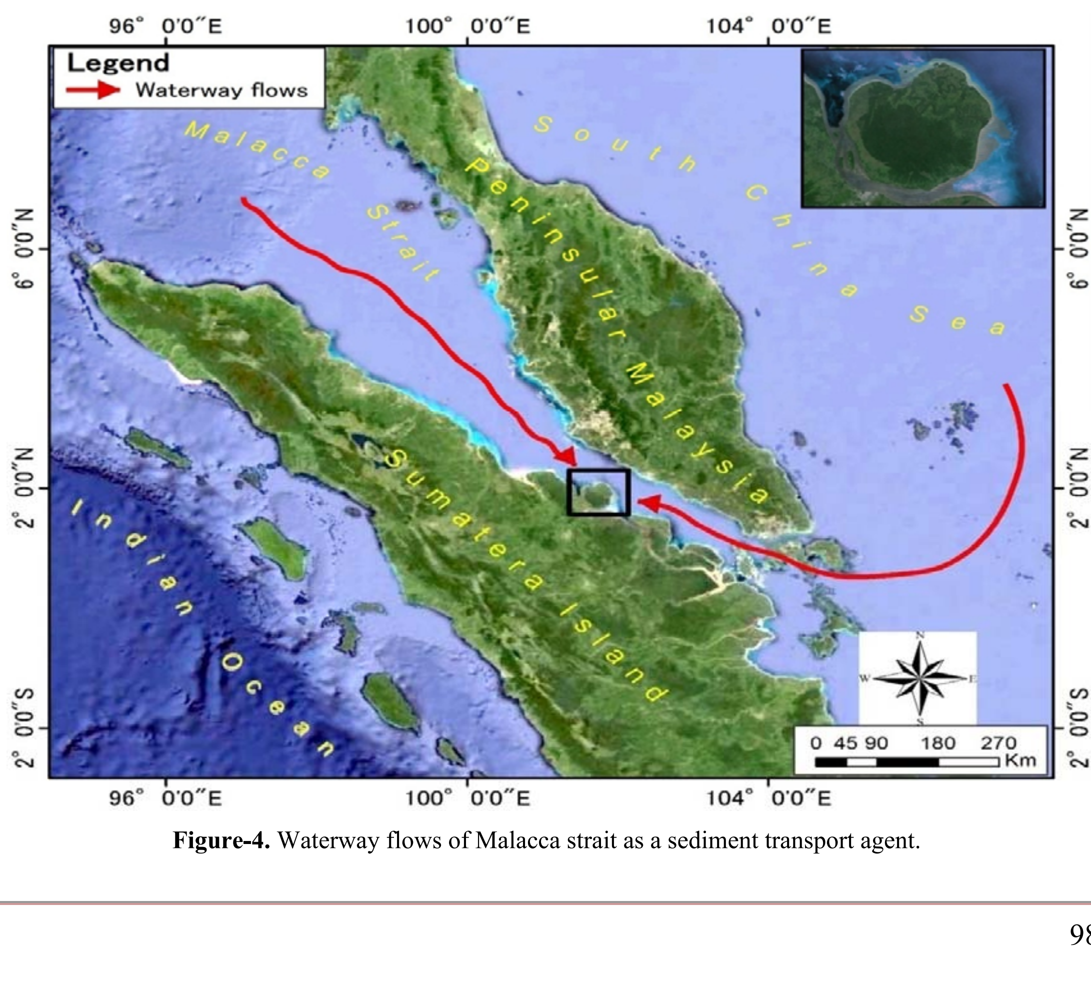

Figure-4. Waterway flows of Malacca strait as a sediment transport agent.

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The microscopic photograph (Figure-5) represents the study area in Beting Aceh, Tanjung Api, Teluk Rhu, Tanjung Punai, and Tanjung Lapin. The microscopic photograph to show the grain size of silica grain was taken, the grain size of silica mineral particles that have virtually the identical size and shape. Refer to the sedimentary provenance and its associations with sedimentary transportation agent [19, 20], sedimentary grain shape and grain size characteristic of silica mineral on the northern coastline of Rupat Island are rounded and the shape size is virtually identical. This mean silica mineral was transported from far location / source. This analysis also supported that silica mineral was not produced by this island bedrock.

All samples from the observation locations shown the properties of silica mineral are virtually white and homogeneous by direct observation in the field (Figure-6). It gives the suggestion that silica mineral composition in this area almost have the same content.

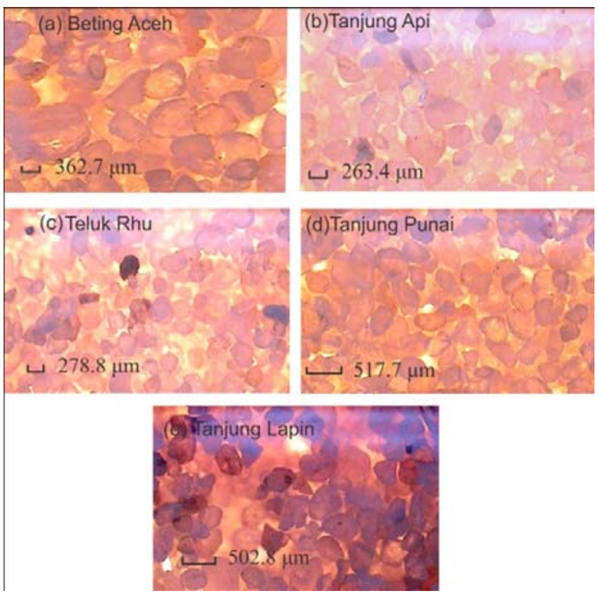

Figure-5. Grain size from microscopic photograph of Silica mineral samples from each observation location shows that shape and grain size is virtually same.

4.3 Silica percentage

To determine the content of silica percentage and the compound of mineral properties, laboratory testing was used in the sand samples obtained from the field survey. The chemical analysis of silica mineral samples needs to get the types of compounds/elements, physical properties and percentage content of the compounds/elements.

Laboratory test using XRF (X-Ray Fluorescence) shows the abundance of compounds such as SiO_2 (Silicon dioxide), TiO_2 (Titanium dioxide), Al_2O_3 (Aluminum oxide), Fe_2O_3 (ferric oxide), MnO (Manganese (II) oxide), MgO (Magnesium oxide), CaO (Calcium oxide), Na_2O (Sodium oxide), K_2O (Potassium oxide) and P_2O_5 (diphosphorus pentoxide). The result shows the compound of silica (SiO_2) has the high percentage amount above 95% compare to the other minerals in the same samples. The second abundances mineral in these samples is Al_2O_3, which the average number of it percentages around 0.70% and followed by another mineral as the small number of the samples from northern part of Rupat Island. XRF test shows the percentage content of compounds/minerals (Table-1) for five observation locations (Beting Aceh, Tanjung Api, Teluk Rhu, Tanjung Punai and Tanjung Lapin).

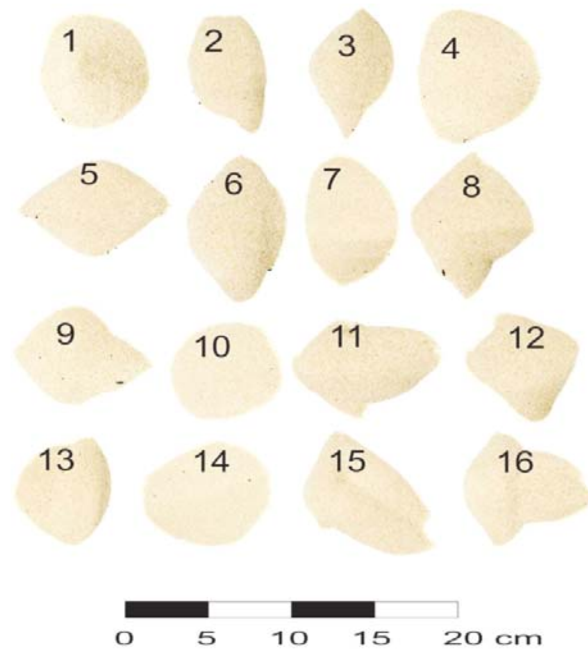

Figure-6. Silica mineral samples from the Northern coastline of Rupat Island.

Table-1. X-RF result of Silica percentage of the Silica sand samples from Northern part of Rupat Island.

Mineral	BA	Tap	TRh	TPn	TLp
SiO_2	98.42	97.89	97.45	97.83	98.06
TiO_2	0.19	0.09	0.09	0.07	0.26
Al_2O_3	0.55	0.69	0.85	0.67	0.65
Fe_2O_3	0.38	0.35	0.36	0.36	0.48
MnO	bdl*	bdl*	bdl*	bdl*	bdl*
MgO	0.10	0.10	0.10	0.12	0.12
CaO	0.18	0.20	0.21	0.20	0.20
Na_2O	0.05	0.65	0.19	0.09	0.07
K_2O	0.22	0.32	0.48	0.32	0.23
P_2O_5	0.01	0.01	0.01	0.01	0.01
L.O.I**	0.40	0.32	0.33	0.41	0.41

bdl*: below detection limit
L.O.I**: lost on ignition

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From laboratory test using XRD (X-Ray Diffraction) instrumentation, the result show of quartz mineral abundance. It summarizes the content of quartz mineral fully-loaded in those samples. The samples were measured based on the in-situ sample of the silica mineral on the northern coastline of Rupat Island. XRD results show other minerals in the sample, but the total is very small compared to the quartz mineral. The result showed that quartz mineral is a dominant mineral in the samples and can be concluded as the homogeneous quartz sand samples. By this conclusion, the samples taken from this area can be defined as the homogeneous quartz sand which is distributed along the northern part of the Rupat Island area.

From Figure-7, the highest peak of the XRD result shows the quartz mineral is on 1650 in CPS (count per second). From Figure-8, the highest peak of the XRD result shows the quartz mineral is on 1800 in CPS. From Figure-9, the highest peak of quartz mineral is on the 1850 CPS. Continue to the Figure-10, the highest peak of the quartz mineral is on the 1600 CPS. The last result taken from XRD testing, Figure-11, shows the highest peak of quartz mineral is on the 2100 CPS. The highest peak shows the dominant mineral in the sample, while the other peak shows the abundance of mineral.

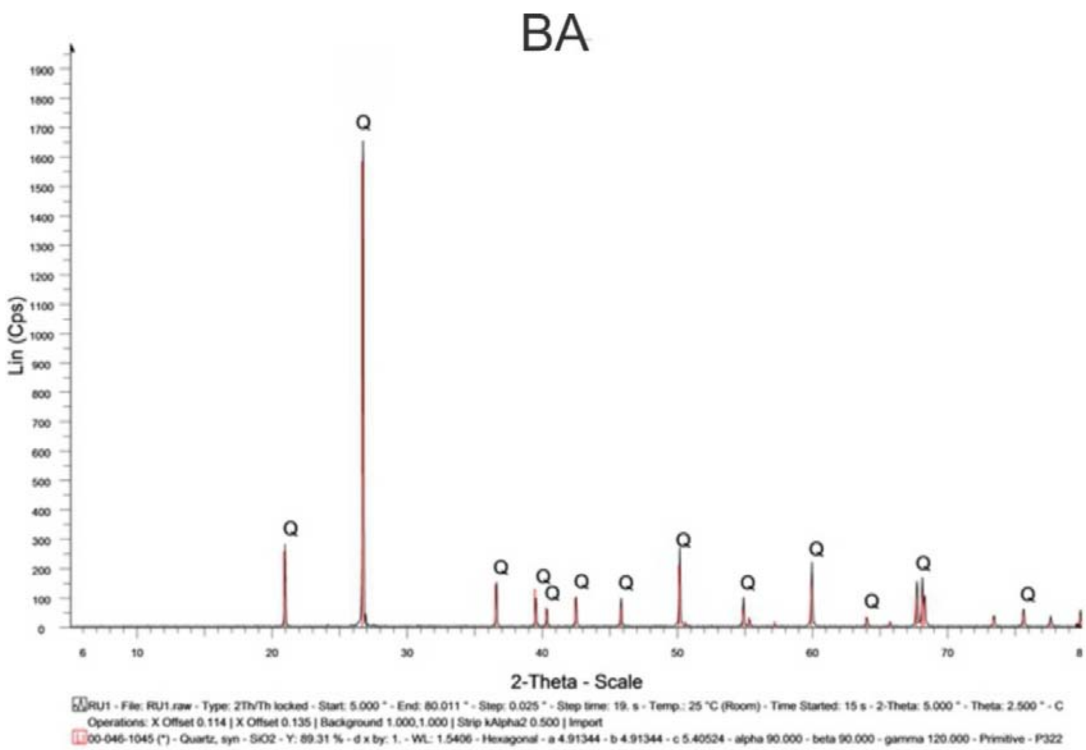

Figure-7. X-Ray Diffraction profile from Beting Aceh (BA) sample.

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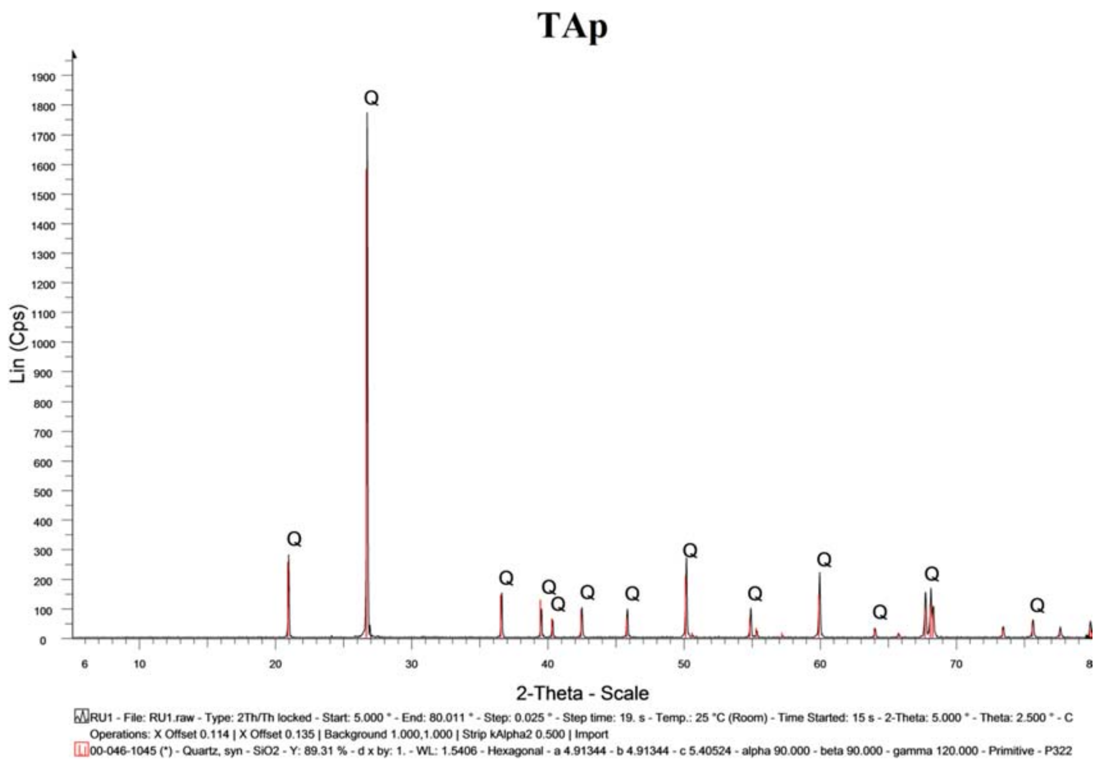

Figure-8. X-Ray diffraction profile from Tanjung Api (TAp) sample.

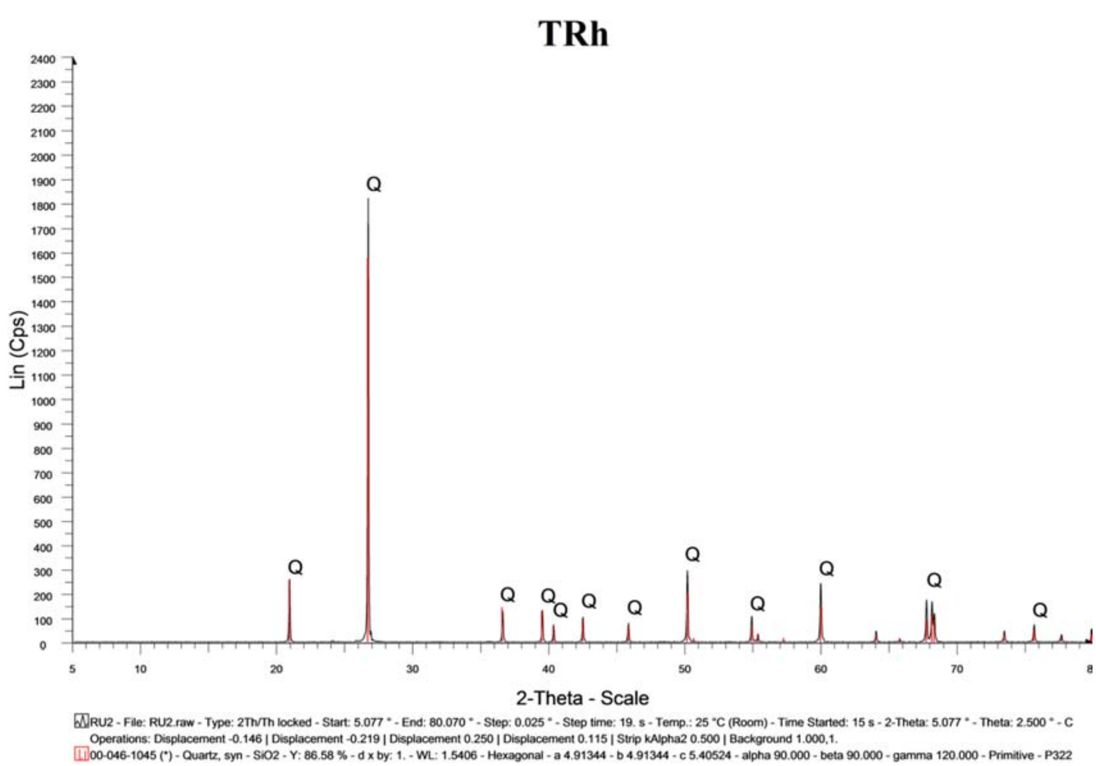

Figure-9. X-ray diffraction profile from Teluk Rhu **(**TRh**)** sample.

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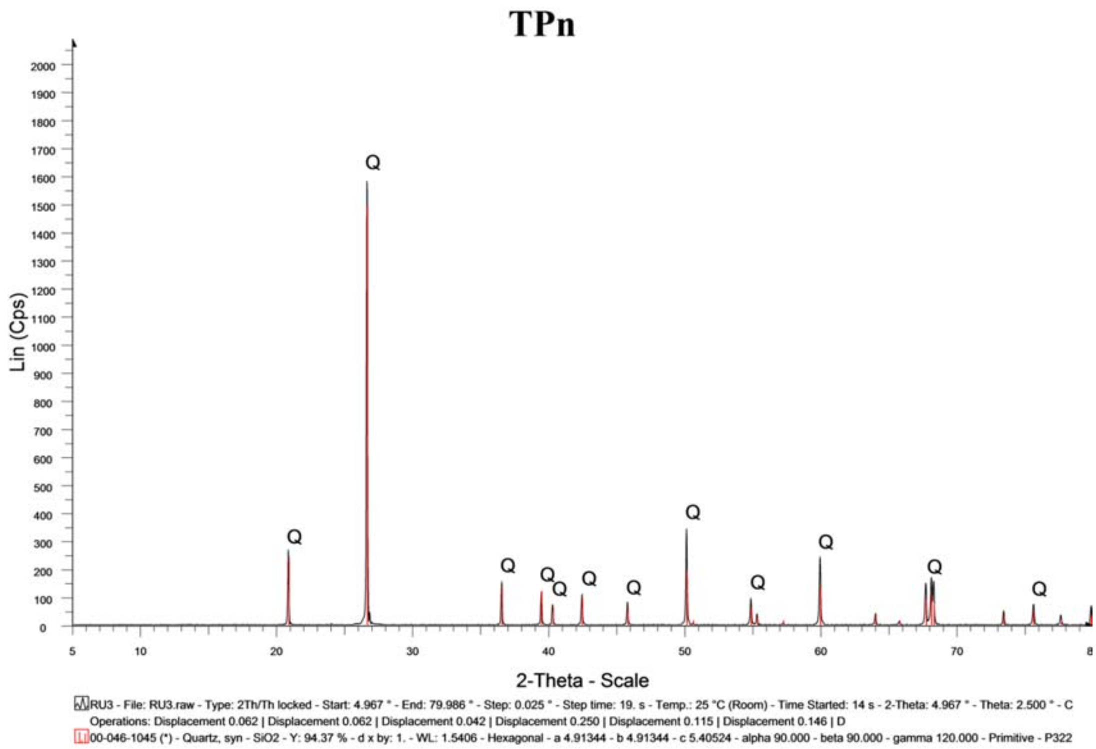

Figure-10. X-ray diffraction profile from Tanjung Punai **(**TPn**)** sample.

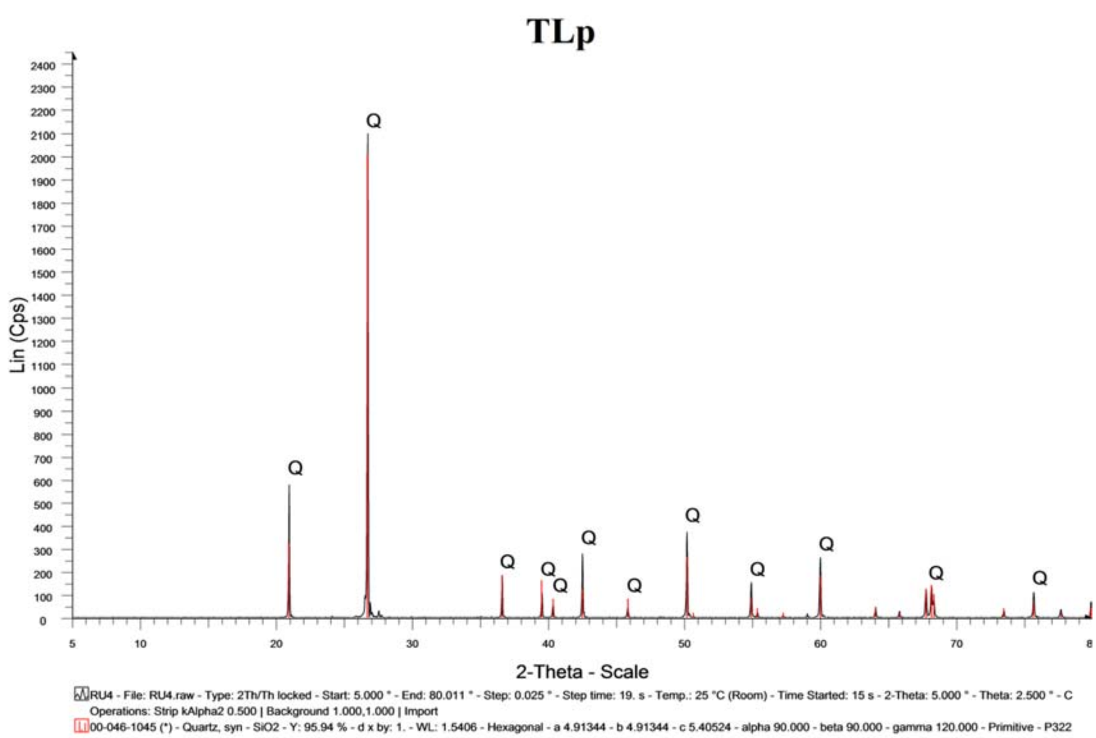

Figure-11. X-Ray diffraction profile from Tanjung Lapin **(**TLp**)** sample.

5. CONCLUSIONS

Research on the potential distribution and high percentage of silica mineral in the northern part of the Rupat Island shown the results have the high silica content above 95%. The origin of the silica mineral is not from the

Rupat Island bedrock, but it came from the Malacca Strait which brought the sediment source.

The high content of silica can be utilized for the use of industrial raw materials. From the results obtained, the points can be determined as the potential for mining activities.

In addition to mining activities, the planning for this activity needs detail calculation carefully. Besides of the mining activities, the other potential for this area is the development of the tourism industry, because the island has a white-sand beach that stretches along the northern coast. The mining industry and tourism can be combined in an appropriate setting because the island shoreline Rupat northern part is very long.

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